Journal of Economic Geography **13** (2013) pp. 1–22
Advance Access Published on 31 July 2012

doi:10.1093/jeg/lbs022

Innovation and spatial inequality in Europe and USA

Neil Lee and Andrés Rodríguez-Pose**,†*

*Department of Economics, Lancaster University Management School, Lancaster LA1 4YQ, UK & Socio-Economic Research Centre, The Work Foundation, 21 Palmer Street, London SW1H 0AD, UK
**Department of Geography and Environment, London School of Economics, Houghton St., London WC2A 2AE, UK
†Corresponding author: Andrés Rodríguez-Pose, Department of Geography and Environment, London School of Economics, Houghton St., London WC2A 2AE, UK. *email*: <a.rodriguez-pose@lse.ac.uk>

Abstract

Innovation is a crucial driver of urban and regional economic success. Innovative cities and regions tend to grow faster and have higher average wages. Little research, however, has considered the potential negative consequences: as a small body of innovators gain relative to others, innovation may lead to inequality. The evidence on this point is fragmented, based on cross-sectional evidence on skill premia rather than overall levels of inequality. This article provides the first comparative evidence on the link between innovation and inequality in a continental perspective. Using micro data from population surveys for European regions and US cities, the article finds, after controlling for other potential factors, good evidence of a link between innovation and inequality in European regions, but only limited evidence of such a relationship in USA. Less-flexible labour markets and lower levels of migration seem to be at the root of the stronger association between innovation and income inequality in Europe than in USA.

Keywords: Innovation, inequality, European Union, USA, cities, regions
JEL classifications: O31, D31, R13
Date submitted: 30 May 2011 **Date accepted:** 20 June 2012

1. Introduction

Policymakers and academics have put great emphasis on innovation as the key to creating successful urban and regional economies. In the European Union, this has been best expressed through the Lisbon Agenda and Europa 2020, which aimed and still aim, respectively, to generate a dynamic, smart, innovative and sustainable European economy and address the continental innovation gap with USA. Similar policies have been attempted in USA, which—while more innovative than Europe—sees investing in innovation processes as essential to maintaining competitive advantage, increasing productivity and creating new jobs. As cities are seen as key sites for the generation of innovation, much of this policy takes place at the urban and regional level (Acs, 2003; Audretsch and Feldman, 2003). This emphasis on innovation is supported by a wide body of research which suggests that individuals in innovative firms, innovative occupations and innovative cities command higher wages than those who are not (Van Reenen, 1996; Faggio et al., 2007; Echeverri-Carroll and Ayala, 2009).

Yet despite this focus, little research has considered the potential negative consequences of urban innovation. A number of processes have been suggested through which innovation may affect the wage structure, and potentially increase

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inequality. Innovation produces gains, which are likely to accrue to particular individuals, often those with complementary skills or working in innovative sectors (Van Reenen, 1996; Faggio et al., 2007; Echeverri-Carroll and Ayala, 2009). It may create knowledge spillovers, which only increase productivity for those who have the capacity to use them. Affluence for one group may skew the labour market for others, creating jobs in personal service employment on low wages (Manning, 2004; Kaplanis, 2010a). Alternatively, innovation may make these cities more equal. Innovative cities tend to grow faster, and growth may benefit those with lower skill levels whose wages are bid up (Wheeler, 2004a). Knowledge spillovers may allow those with fewer skills to learn from the highly skilled, increasing their productivity as they have a greater range of potential learning partners (Glaeser, 1999). These processes will depend significantly on the particular socio-economic and institutional context. They will also be affected by the particular economic geography in which innovation takes place, dependent on movements of labour and capital and the extent to which these produce or follow innovation (Crescenzi et al., 2007). This means the extent to which innovation leads to inequality at a sub-national level is likely to vary continentally.

So far few studies have considered the links between innovation and inequality at a local level (Florida, 2005; Donegan and Lowe, 2008). Some of these studies provide cautious evidence of a link between innovation and inequality for European regions (e.g. Lee, 2011). However, work on US cities has tended to focus on skills premia, which ignore the wider distribution of skills in the population (Glaeser et al., 2009). For example, Echeverri-Carroll and Ayala (2009) show that while workers in innovative cities earn more, those who have higher-levels skills tend to gain more than those who do not. Similarly, Florida (2005) documents a greater wage ratio between those who work in innovative ‘creative class’ occupations and those who do not, which he suggests implies increased overall inequality.

In focusing on skills premia, existing work tends to ignore the distribution of skills, and how patterns of migration may lead this to differ across cities. Existing research is also almost exclusively based on cross-sectional regressions. And in using such a diverse set of methodologies and indicators for inequality and innovation, it becomes hard to assess how these processes differ by continent. Yet, a continental approach provides insights into how localized processes of innovation, combined with both geographical factors and differing welfare regimes and institutions, may lead to particular outcomes. This is important as it allows an understanding to be developed of how levels of urban or regional inequality are shaped by continental, as well as local, trends. There is thus a gap in the evidence on the link between innovation and inequality at a sub-national scale, the extent to which this varies between Europe and USA, and the way in which the other determinants of inequality differ between the two continents.

This article presents the first comparative assessment of the link between innovation and inequality in European regions and US cities. It uses data from the Current Population Survey (CPS), a survey of $\sim$130,000 individuals conducted annually in USA, and the European Community Household Panel (ECHP) Survey, a survey of $>$100,000 individuals across 13 European countries. These are used to create measures of inequality which are introduced as the dependent variables in a series of fixed effects panel regressions investigating the link between innovation and inequality. The model controls for time invariant regional characteristics and for other potential explanatory variables, such as the skills distribution or economic growth.

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The evidence lends support for the hypothesis that innovation drives inequality, but also displays the existence of significant differences in the relationship between innovation and inequality across continents. In the case of Europe, there is relatively strong evidence that the overall level of innovation leads to greater inequality in regions. In contrast, there is no general link between patenting and inequality in USA, where the effect is limited to innovation in the sub-categories of biotechnology and ICT patenting. One explanation for this is that the greater mobility of labour in USA allows individuals to enter innovative US labour markets and share in the wage gains from innovation. These processes will not operate in Europe, where labour markets are less flexible and have lower levels of migration. Where innovation raises wages for individuals, the compensatory movements of labour are less likely to operate, meaning that only certain groups benefit. Alongside this, different market structures will condition the link between innovation and inequality. Innovation may lead to inequality in a number of ways, many of which may still operate in certain sub-sectors even if they do not apply generally. Innovation processes in industries such as ICT may still operate to drive inequality in USA, but these processes do not generalise to the overall level of innovation. The results also suggest that there are two separate processes operating, in Europe at least: one process through which innovation leads to growth, which reduces inequality, and another through which—controlling for growth—innovation increases inequality.

The results suggest some additional differences in what determines urban and regional inequality in the two continents. The distribution of education in the population and the average wage are important in both USA and Europe. Population density, in contrast, appears to lead to reduced inequality in Europe, but increased inequality in USA [in contrast to other research for USA (Wheeler, 2004b)]. Cities with higher unemployment rates in USA are more unequal, but the same relationship does not hold for European regions, possibly due to the role of labour market institutions propping up wages at the bottom of the distribution.

The article is structured as follows. Section 2 reviews the literature on the determinants of inequality in US cities and European regions, focusing on the key explanations of the level of development, urban or regional population density, migration and the level of innovation. Section 3 outlines reasons why these determinants may differ between the European and US contexts. Section 4 outlines the model and the data, and Section 5 considers the results of these models. Section 6 concludes with the implications for theory in this area.

2. Innovation and inequality in cities and regions

Research on the links between innovation and inequality has tended to focus on the idea of skill-biased technological change (SBTC) and its implications for employment for different skill groups. The simplest version of this theory suggests that technology will substitute for low-skilled labour, reducing employment shares for the low skilled and also their wages. High-skilled jobs, for which technology is a complement, will see increased wages and employment shares. Recent theory in this area has focused on the decline of the middle of the distribution, rather than the bottom. Autor et al. (2003) suggested that technology would instead substitute for routine semi-skilled employment, such as bookkeeping, which could more easily be automated. Routine non-skilled employment, such as cleaning, still required irregular, context specific activity and

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would be difficult to automate. So technological change would lead to a polarization of the labour market into high-skilled and low-skilled employment. Evidence has been found at the national level for both of these effects, while more recent work has tended to favour the latter (Lemieux, 2008).

Little research has considered the impact of innovation on inequality at a local level, however, and the determinants of inequality in cities or regions remain far from well understood (Lobao et al., 1999; Dickey, 2007; Rigby and Breau, 2008; Glaeser et al., 2009). A number of interrelated processes may contribute to this link between innovation and inequality in urban and regional contexts. The first of these is the simple composition effect, as those who work in innovative occupations or innovative firms will gain from processes of wage sharing. There is good evidence that individuals working in innovative firms earn more than those outside (Van Reenen, 1996; Faggio et al., 2007). Innovative workers are likely to be more skilled, to earn higher wages, may experience greater demand for their services and are more likely to set up their own firms. As, by definition, innovative cities concentrate more innovators, greater urban and regional inequality will be the likely outcome.

Secondly, the presence of affluent innovators in the labour market will alter both the occupational structure and wages for those with low skill levels. In her studies of global cities, Sassen (2001, 2006) suggested that a class of highly-paid workers in 'command and control' industries hired low paid, predominantly migrant workers in personal service occupations, such as cleaning, waiting on tables or working as janitors. The high opportunity cost of the time of skilled workers will lead to the outsourcing of traditionally home based activities—such as childcare, caring for older people, cleaning and cooking—to those with lower skill levels (Mazzolari and Ragusa, 2007). These activities cannot be performed elsewhere, as they are reliant on proximity to the affluent. Similar processes have been observed in innovative places like Silicon Valley (Finegold, 1999).

An important implication of this theory is that employment and wages at the bottom of the distribution are increasingly linked to wages at the top (Wessel, 2005). But the effect of such employment on inequality is not completely clear, however. While increased demand for low-skilled labour may increase their wages, there may also be a process of squeezing out whereby low value (but relatively higher waged) tradable manufacturing industries are priced out of innovative urban economies. Similar processes have been shown to apply in UK regions and travel to work areas (Manning, 2004; Kaplanis, 2010a). Yet other research has suggested that this increased demand for low waged employment may push up wages at the bottom. Mazzolari and Ragusa (2007) test this relationship for US cities, and find that those low-skilled workers employed in co-location activities have experienced wage growth which is more closely related to wage growth at the top of the distribution.

Moreover, the extent to which personal service activities are outsourced across Europe will differ from that in USA or UK. In a series of studies, the applicability of Sassen's thesis to Europe was questioned on three basic fronts. First, higher minimum wages and a more developed welfare state would shape the way the lower end of the labour market works (Hamnett, 1994). Secondly, social differences linked into the economic processes will affect the outsourcing of these activities as well. Freeman and Schettkat (2001) document a key difference between USA and EU in the extent to which traditional household activities (such as cooking, cleaning and looking after children and elderly people) is produced in the market rather than undergone within the

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household. In European countries, these tend to be performed within the household or by the state, while in USA they are more often marketized.

Migration provides the third front. Differences in the flows and composition of internal migration trends between Europe and USA may either increase or reduce inequality (Korpi, 2008). Low-skilled migration, of the type Sassen observed in global cities, may reduce wages at the bottom of the distribution. It may also reflect latent demand, with wages in the sector bid upwards (Autor and Dorn, 2010). Similar processes may be operating throughout the labour market, with demand for innovative workers attracting highly skilled migrants.

Because it affects both skills premia and the distribution of skills, the impact of migration on overall inequality will be ambiguous. Where cities have few highly skilled residents but experience high-skilled in-migration, it may first increase inequality, but after a certain threshold, it may begin to reduce inequality (although this will depend significantly on how inequality is measured). Traditional models of labour markets imply that this process of migration will reduce wages for the highly skilled. More recent models based on increasing returns suggest that there will be increasing returns to scale when the highly skilled migrants cluster, with more highly skilled migrants leading to even greater increases in innovation (Puga, 2002). Empirical evidence at a national level tends to support this view (Chellaraj et al., 2005), as does case study evidence of the most innovative places. For example, Saxenian (2006) shows the important role of migrants in creating innovation in Silicon Valley.

In general, studies investigating the impact of migration on urban inequality report only small effects. Card (2009) shows that migration has a small effect on inequality in US cities, driven less by the effects on the relative wages of the US born and more by the skills composition of the migrants and so their wages. As immigrants tend to have relatively polarized skill levels, an influx of immigrants tends to increase inequality. This finding is reflected in other studies which have shown that the effect of immigration on inequality depends largely on the composition of the migrant groups (Glaeser et al., 2009).

The above processes imply that innovation will increase inequality, but it is possible that the alternative will occur, with innovation reducing inequality. It may be that processes of learning from those nearby mean innovation leads to productivity increases for those with low skills. This idea has been used to explain the tendency of agglomeration to increase wages for the low skilled (Glaeser, 1999). Those with high skill levels have relatively few individuals they may learn from, as only a small number are more skilled than they are. But the low skilled have a larger number of potential learning partners, as by definition more individuals have higher skill levels. In this case, agglomeration increases the potential learning partners by more for the low than the high skilled, and so reduces inequality as low-skilled productivity increases more. While this explanation has been used to assess the distributional consequences of agglomeration, it can also be generalized to the impact of innovation. In innovative, knowledge-rich environments, those with lower skill levels may learn more and gain from innovation. The counter-argument, of course, is that it is not clear that the knowledge from innovation is of sufficiently wide usability to raise productivity for low-skilled groups, and many of those groups will not be in occupations in which they can benefit from this new knowledge.

Another explanation may be linked to migration and the role of the welfare state. In developed welfare states with low rates of migration—as is the case in Europe—higher wages resulting from innovation are not leading to influxes of new migrants to perform

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low-skilled service work, but rather reducing supply. This scarce supply means that those offering personal services will command higher wages, with their wages increasing in line with the increased productivity of the innovative individuals. Yet, in USA this will not apply, as low welfare rates and high migration rates mean that innovation leads to increased migration, pushing down wages for the low skilled.

None of these explanations include reference to the amenity value of innovative cities. As a number of theorists have suggested, innovative individuals may gain some value from being in an innovative city with a 'buzz' or a high quality of life (Adamson et al., 2004; Storper and Venables, 2004). Innovative individuals may be willing to accept some reduction in wages to live in an environment like this. In contrast, innovative individuals who live outside of these innovative cities may require higher wages than those outside to compensate for this. Thus, the amenity benefits of living in an innovative place may lead to reductions in inequality.

A feasible alternative is that the causality is reversed, with inequality either restricting or increasing innovation (Rodríguez-Pose and Tselios, 2009a). If affluent individuals have preferences for new or advanced goods, they may stimulate innovation in this way (Bertola, 2000). It might be that the affluent fund research or support the arts, and this creates new areas of innovation. This link between the patronage of the very rich and innovation has been observed in cities undergoing extremely creative periods (Hall, 2000). But the unequal distribution of income may also concentrate wealth in the hands of individuals with relatively homogenous preferences, and so reduce incentives to create new products. Where there is a more equal income distribution and individuals have preferences for diverse goods, this may be more likely to stimulate innovation. This may particularly be the case where individuals are seeking to differentiate themselves through consumption and seek out new, interesting and innovative products in order to do so.

Research in this area has been limited. Case studies of cities tend to support the link between innovation and inequality (Florida, 2005; Donegan and Lowe, 2008). For example, Finegold (1999) shows that the development of an innovation-led economy in Silicon Valley has increased income inequality. Empirical work has focused on skill premia, such as Echeverri-Carroll and Ayala (2009) who find a tech-city wage premium which is higher for the highly skilled than other skill groups. But such exercises ignore the distribution of skills in the population (Glaeser et al., 2009). Investigating only European regions, Lee (2011) finds evidence of a link. No evidence has considered these relationships in a cross-continental situation. Yet, the impact of such phenomena will differ both within and between Europe and USA, dependent on processes and levels of innovation, geographical factors and welfare state and employment regimes.

3. Spatial inequality in Europe and USA

There are three related reasons why the processes which link innovation and inequality may have very different impacts in Europe and USA: USA has higher levels of innovation, factor mobility operates to a greater degree and labour market institutions differ significantly between both continents. First, while there is considerable diversity in innovation performance within Europe, as a whole the continent lags behind USA. This innovation gap is driven by a number of factors. USA devotes greater resources in the form of Research and Development (R&D) spending to innovation (Crescenzi et al., 2007). R&D spending was significantly higher in USA than in the major European

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nations. In 2008, USA spent 2.77% of GDP on R&D compared to 1.88% in UK, 2.02 in France, 2.53% in Germany and only 1.18% in Italy (OECD, 2010).[1] Only the Scandinavian nations invested more, with R&D intensity being 3.49% of Finnish GDP and 3.75% in Sweden. Alongside this, research Universities in USA are also generally of a higher standard (Crescenzi et al., 2007). And, cultural factors may reduce the adoption of innovative technologies, with individuals in USA often more open and optimistic about the introduction of new technologies than those in Europe (Gaskell et al., 2005).

Underlying this innovation gap, and with consequences for the determinants of urban inequality, are the levels of mobility of labour and firms. USA has been more open to highly skilled migrants than Europe (Chellaraj et al., 2005; Crescenzi et al., 2007). USA has fewer barriers to internal migration, with a common language, systems of regulation and a more culturally accepting attitude towards movement. Similar processes operate with firms, which tend to move more and move more freely. Greater factor mobility allows the clustering of economic activity into specialized areas, with agglomeration of specialized activity key to the production of new knowledge and innovation (Moreno et al., 2005; Crescenzi et al., 2007; Sonn and Storper, 2008). The more cohesive and homogenous market in USA provides greater opportunities for specialization of production and consumption (Crescenzi et al., 2007). As a result, economic activity in USA is more concentrated in space than economic activity in Europe (Puga, 2002). In turn, this proximity facilitates the exchange of economic knowledge, and face to face contact provides a more efficient form of generating trust and learning and so reducing transaction costs (Storper and Venables, 2004).

The sorting of economic activity into its most productive location may lead to inequality through complementarities between cities and skills (Glaeser et al., 2009). But processes through which economic activity increasingly specializes into particular sectors can lead to greater equality, as local economies become increasingly homogenous. As shown by Wheeler (2007), specialized cities may be more equal, as localized manufacturing industries are more equal than those which are more dispersed.

The third area of difference is related to labour market institutions, both formal and informal, which operate in both continents. Atkinson (1997) suggests that institutional factors are important in moderating the impact of supply and demand on wages, with particular institutional characteristics leading to particular results. In general, USA has relatively laissez-faire coverage. Unions are less powerful and cover fewer workers (Freeman, 2007). These regimes will also alter the extent to which individuals can enter the labour market, and so affect the wage structure (Gallie and Paugman, 2000). Minimum wages differ by country, but tend to be higher than in USA, with their impact varying by the level at which the minimum wage is set (Dickens and Manning, 2004). The extent to which the state intervenes to support employment also varies. While the public sector has been shown to help support lagging regions in maintaining quality jobs, it may reduce inequality and affect processes which would otherwise redistribute labour to particular areas (Lobao et al., 1999; Volscho and Fullerton, 2005).

Different labour market regimes will alter the extent to which differences in raw productivity translate into outcomes on the ground (Tselios, 2008). However, there are

1 The figure given for Germany is for 2007. The respective figures for 2001 were: USA—2.72, UK—1.79, France—2.20, Germany—2.46, Italy—1.09, Finland—3.3 and Sweden—4.17.

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some differences between US states (and so cities) in taxation and welfare rules (Card and Krueger, 1993). These will shape the extent innovative gains can be captured by particular groups. There is also considerable diversity of welfare state regimes across Europe, dependent on historical trajectories and the degree of devolution of power (Esping-Andersen, 1990; Gallie, 2007; Costa-Font, 2010).

There are thus important reasons to suspect that the impact of innovation on inequality will differ between Europe and USA. In the remainder of this article, we test whether innovation in a city or region leads to inequality and whether this differs in Europe or USA.

4. The model and data

4.1. The model

To test the link between innovation and inequality, a model is used which estimates the level of inequality in a city or region as a function not just of innovation, migration and labour market institutions, but of a set of other factors which the literature has identified as influencing interpersonal inequality. These include the education of the population, density, affluence and unemployment rate. The model adopts the following form:

$$\begin{aligned}\text{Gini}_{it} = \alpha + \beta_1\ \text{HighSkill}_{it} + \beta_2\ \text{PopDen}_{it} + \beta_3\ \text{Income}_{it} + \beta_4\ \text{Unemp}_{it} + \\ \beta_5\ \text{Migration}_{it} + \beta_6\ \text{WageCoord}_{it} + \beta_7\ \text{Innovation}_{it} + \text{v}_i + \varepsilon_{it}\end{aligned}$$

where, for city or region '*i*' at time '*t*', Gini is the measure of Gini wage inequality amongst normally working people in the US city or European Region. HighSkill is a measure of human capital, proxied by the proportion of the population qualified to a higher education degree level or above. PopDen is a measure of urban scale, depicted by the density per square kilometre of the population of the region or city. Income is a measure of the median wage in USA, or regional GDP in Europe. Migration is the migration balance, or the difference between the natural increase in population, as given by net births and deaths, and total population growth. WageCoord is a measure of wage coordination at the national level for European countries. Innovation is a measure of the level of innovation in a city or region. The time invariant error is 'v' and the remaining error term is 'ε'.

4.2. European data

The principal source of data for the European Union is the ECHP. This is a sample survey of ~100,000 individuals in 13 European countries: UK, Portugal, France, Germany, Spain, Greece, Ireland, Italy, Austria, Finland, Denmark, Luxembourg and Sweden. Data are given at the level of Nomenclature of Territorial Units for Statistics (NUTS), the standard European statistical regions. These are available at the larger NUTS 1 level for all countries except for that of the UK and Portugal, where NUTS 2 data are available. To ensure comparability between the ECHP regions and those of the controls, a number of European boundaries have been merged and Denmark and Finland are included as single regions. This results in a sample of up to ninety three regions.

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4.3. US data

The principal source of data for USA is the CPS microdata. This is an annual sample survey of ~60,000 households or 130,000 individuals across USA. The data are provided by the IPUMS CPS service at the University of Minnesota. These data are used to construct indicators of inequality and other independent variables for a set of US Metropolitan Statistical Areas. Most variables are harmonized for use, making them comparable over time. A maximum of 70 cities can be matched with data for patenting. The data are available from 1962, but there was a major reorganization between the years 1993 and 1995, while the full set of variables used here is only available from 1996. Here, two periods are used: to maximise comparability with the European data, the period 1996–2001, and in order to extend this to the most recent possible data, the period 1996–2009 is also used.

CPS data are coded at the Metropolitan Statistical Area level. There are two major issues with this; first the boundaries change over time, with cities dropping in and out of the panel. A second related issue is that it is not possible to match all data with the control variables. These two problems mean that the data form an unbalanced panel. The use of fixed effects methods should minimise some of these problems, as they essentially consider within variation for particular cities. Given the continental scope of this article, issues such as this are perhaps unavoidable. Nevertheless, it suggests that caution is needed in interpreting the results.

4.4. Dependent variable

The dependent variable is the Gini coefficient of gross weekly income among normally working people. From the ECHP, the measure used is wage income, calculated as the 'Total Net Income from Work' (ECHP Question PI110) for those whose income is greater than nought and who are normally working (working >15 h per week). This measure includes wages and salaries and bonuses from employment (or self-employment) after tax. From the CPS, the measure used is the variable *incwage*, wage and salary income. As with the European data, the sample is restricted to those who are working >15 h a week.

4.5. Measuring innovation

The measure of innovation used here is patenting; in particular, the number of patents filed per million inhabitants. For Europe, these data come from Eurostat (2010). For USA, the data come from the OECD Regpat database. The key measure is the overall measure of patenting, which is available for both Europe and USA. Alongside this, several sub-indicators are used. For Europe, three measures are available: biotechnology patenting, high-tech patenting and ICT patenting. For USA, alongside the overall measure of patenting are measures for biotechnology patenting and ICT patenting. The key strength of using patenting as a proxy for innovation is that it is an output of innovation rather than an input, and so may be a better measure than R&D spending or high-technology sectors. However, it ignores innovation which is not patented (such as process innovation) and it cannot account for the success of the innovation, or the extent to which it is successfully commercialized.

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4.6. Independent variables

The models include controls for other potential determinants of inequality. The key debate on the determinants of inequality at a national level has been the impact of economic development. This was suggested in a seminal paper by Kuznets (1955), who proposed the inverse U-shaped model of economic development. The model starts with each region having a purely low-wage agricultural labour force, but one which is gradually making the transition into a high-wage, urban manufacturing sector. As the region develops, the first workers move to the manufacturing sector, earning higher wages and so increasing inequality. After a certain threshold, more and more workers earn higher wages, and so each additional worker moving into manufacturing leads to a decline in inequality. In this manner, inequality takes an inverse U-shaped relationship with development, with inequality first increasing but subsequently falling.

To control for the impact of levels of economic development, a variable for the average wage is used. In Europe, there is full data on regional GDP per capita. In USA, this is calculated using the same measure of income as the gini coefficient, as the median for individual wages for those who are working >15 h per week, a similar measure used by other studies (Lobao et al., 1999). Research for both USA and Europe has shown that economic growth has been linked with reductions in inequality (Wheeler, 2004a; Tselios, 2008; Lee, 2011). However, other research has considered the possibility of a U-shaped relationship (Nielsen and Alderson, 1997).

Secondly, a dominant area of research has been on the impact of migration on inequality (Card, 2009; Glaeser et al., 2009). There is no variable on recent migration at the city level in the CPS, so the variable used here is the proportion of the population in the CPS who were not resident in the same state in the previous year. This is the best available measure of migration at a local level. Although it will not include those who move within the same state, it will include international migration and those who move across states. Note that results are broadly the same if an alternative measure of international migration, the proportion of the population of the city who were born in USA, is used. There is no similar data on migration as part of the ECHP, so the variable used here is the migration balance. This is calculated as the difference between natural population change (total births minus deaths) and the change in population in the period before, giving a measure of migration relative to the overall population in each period (Furceri, 2006).

Third, it is important to control for national level institutional changes, as these will condition the extent to which economic processes lead to changes in inequality. To control for these changes, a variable for the wage co-ordination at a national level is used. This is appropriate as most institutional changes occur at the national level although, of course, the data cannot account for time variant changes in regional institutions. The measure used is taken from the Database on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts by Visser (2009) at the University of Amsterdam. Note that this is principally of importance for European data, as it controls for national level changes in wage setting institutions. For USA, the measure is invariant for the period in question. As time-invariant variables are partialled out in the fixed effects regressions, this means that the variable is effectively not included in regressions focusing on USA.

A fourth key area of research has been the link between the density and size of local labour markets and inequality. Wheeler (2004b) finds that density is associated with

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reduced inequality in US MSAs. Korpi (2008) investigates this using a set of Swedish local labour markets, finding that larger labour markets tend to be associated with greater levels of inequality. In part, he finds that this is because larger labour markets have different industrial and occupational compositions, particularly increased diversity, which lead to increases in inequality. Given the use of fixed effects models which investigate changes over time rather than actual levels, population density has the same effect as overall population.

Finally, other researchers have highlighted the importance of the skills distribution of the population in inequality (Wheeler, 2005; Glaeser et al., 2009; Tselios, 2008; Rodríguez-Pose and Tselios, 2009a, 2009b). This is fundamental to many interpretations of inequality. For example, Glaeser et al. (2009) suggest that urban inequality is determined by three fundamental variables: the distribution of skills, the relative skills premium (how much skills are rewarded), and institutions which mediate and shape how market processes influence the wage structure.

The names of the variables for Europe and USA included in the analysis, their definitions and their sources are presented in Table 1.

5. Results

The models are estimated as panel data regression. For the European Union, the model is run with a maximum of 93 regions giving 615 observations for the period 1995–2001 using the length covered by from the ECHP. For USA, the CPS provides data for the wider period 1996–2009. This gives an unbalanced panel of up to 70 cities in the period, and up to 519 observations.

Time-invariant city or regional characteristics are highly likely to lead to alter the levels of inequality in particular cities or regions. To control for this, and following the existing literature in this area, the models are estimated with fixed effects (Cameron and Trivedi, 2009; Lee, 2011).

5.1. Innovation and inequality

Table 2 gives the results for the European Union and Table 3 for USA. There is some evidence of heteroskedasticity in the raw data, which leads to logging most variables. The fit for the European models is low, with an R^2 of only 0.018–0.026 for the full models. This fit is, however, in line with other similar studies, reflecting the diverse drivers of inequality and the likely problem of measurement error (Lee, 2011). More importantly, the dependent variables seem to provide a reasonably consistent fit with the data. For US cities, the R^2 value is considerably higher, ranging between 0.065 and 0.108.

The raw regressions between the innovation measures and inequality are given in columns 1–4. Of these, only the overall patenting variable is significantly related to inequality, with a negative sign. The three more specific measures of innovation, biotechnology patenting, ICT patenting and high technology patenting are not significant. It appears that without controls there is only a limited negative relationship between innovation and inequality.

In contrast, the full models suggest that this association is not robust and that innovation leads to increased inequality in European regions, although there is diversity of effect between the different measures. Two of the measures of patenting are

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Table 1. Independent variables

Variable	Description	Source
European Union		
GDP per capita (ln)	GDP per capita in current prices, natural log	Eurostat
Unemployment rate (%)	Unemployed as a percentage of working age population (16–64)	Eurostat
Population density (ln)	Population per square kilometre, natural log	Eurostat
Qualified to degree (%)	% of Population qualified to degree level or above	ECHP
Wage coordination score	Measure of wage co-ordination of the national economy	Visser (2009)
Migration balance	Migrants as percentage of population. Calculated as population changes plus deaths minus births, divided by population (Furceri, 2006)	Eurostat
Patenting per capita	Patent applications to the EPO per million inhabitants, natural log	Eurostat
Biotech patenting per capita	Biotech patent applications to the EPO per million inhabitants, natural log	Eurostat
ICT patenting per capita	ICT patent applications to the EPO per million inhabitants, natural log	Eurostat
High technology patenting per capita	High technology applications to the EPO per million inhabitants, natural log	Eurostat
USA		
Median wage (ln)	The median income in the MSA among those working >15 h a week, natural log	Current Population Survey (CPS)
Unemployment rate	Unemployed as a percentage of the working age population (16–64)	CPS
Population density (ln)	Population per square kilometre, natural log	OECD
Qualified to degree (%)	% Of Population qualified to degree level or above	CPS
Recent migrants (%)	% Of population who lived in a different state in the previous year	CPS
Patents per capita	Patent applications per million inhabitants, natural log	OECD Regpat
Biotech patents per capita	Biotech patent applications per million inhabitants, natural log	OECD Regpat
ICT patents per capita	ICT patent applications per million inhabitants, natural log	OECD Regpat

significant: the overall measure of patenting is significant at the 5% level and positive, while ICT patenting is also positive and significant at the 1% level. Note that when measures of innovation are included in the model, the measure for human capital is not significant (although it is significant when these are not used). This may signal that the importance of human capital is driven by the capacity to use it to generate economically useful knowledge, and this is what drives inequality. In Europe, labour institutions may restrict the extent to which individuals gain from human capital and high employment in the public sector may further reduce skills premia, with innovation being a better proxy.

Controlling for wealth, unemployment, population density, education, wage coordination and migration in Europe, it appears that innovation is leading to inequality. This may be happening for a number of reasons. It may be because of localized processes of SBTC, because of the presence of affluent innovators, because innovative

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Table 2. Patenting and inequality in European regions, 1995–2001

Dependent variable	Gini coefficient of wages							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP per capita (ln)					−0.0338 (0.0105)***	−0.0218 (0.0109)*	−0.0330 (0.0104)***	−0.0261 (0.0118)**
Unemployment rates (ln)					−0.000746 (0.000760)	−0.000222 (0.000943)	−0.000585 (0.000823)	−0.000670 (0.000783)
Population density (ln)					−0.00871 (0.00126)***	−0.00898 (0.000882)***	−0.00976 (0.00107)***	−0.00880 (0.000853)***
Share of population with degree (ln)					0.000163 (0.000139)	0.000200 (0.000163)	0.000198 (0.000134)	0.000260 (0.000162)
Wage coordination					−0.00788 (0.00240)***	−0.00786 (0.00268)**	−0.00777 (0.00209)***	−0.00734 (0.00221)***
Migration balance					−0.364 (0.631)	−0.350 (0.639)	−0.339 (0.687)	−0.277 (0.668)
Patents per capita (ln)	−0.000670 (0.000241)**				0.00430 (0.00148)**			
Biotech patents p.c. (ln)		0.00105 (0.00132)				0.00206 (0.00240)		
ICT patents p.c. (ln)			0.000180 (0.000600)				0.00437 (0.00124)***	
HT patents p.c. (ln)				−0.000229 (0.000618)				0.00248 (0.00177)
Constant	0.337 (0.000851)***	0.332 (0.00135)***	0.333 (0.00136)***	0.334 (0.00123)***	0.660 (0.102)***	0.551 (0.110)***	0.654 (0.106)***	0.590 (0.119)***
Observations	615	521	561	561	490	428	459	458
R^2	0.001	0.001	0.000	0.000	0.025	0.018	0.026	0.018
Number of cases	93	91	92	92	86	83	85	85

Robust standard errors clustered by country. Model estimated with fixed effects.
***$p<0.01$, **$p<0.05$, *$p<0.1$.

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Table 3. Patenting and inequality in US cities, 1996–2009

Dependent variable	Gini coefficient of wages					
	(1)	(2)	(3)	(4)	(5)	(6)
Median wage (ln)				−2.77e−06 (1.34e−06)*	−3.25e−06 (1.51e−06)*	−2.84e−06 (1.30e−06)*
Unemployment rate (ln)				0.00423 (0.00113)***	0.00484 (0.00226)*	0.00421 (0.00138)**
Population density (ln)				0.526 (0.205)**	0.692 (0.168)***	0.505 (0.189)**
Population with degree, % (ln)				0.00248 (0.000654)***	0.00130 (0.00199)	0.00185 (0.000637)**
Recent migrants (%)				0.121 (0.239)	0.0988 (0.188)	0.0717 (0.242)
Patents per capita (ln)	0.0130 (0.0130)			−0.000321 (0.0148)		
Biotech patent p.c. (ln)		0.0132 (0.00758)			0.0202 (0.00909)*	
ICT patents p.c. (ln)			0.0138 (0.00529)**			0.0125 (0.00536)**
Constant	0.563 (0.133)***	0.597 (0.0972)***	0.593 (0.0624)***	−1.417 (0.824)	−1.786 (0.524)***	−1.197 (0.686)
Observations	519	395	481	471	362	439
R^2	0.003	0.007	0.008	0.065	0.108	0.067
Number of cps_code	70	60	66	69	59	65

Robust standard errors clustered by region. Model estimated with fixed effects.
$^{***}p<0.01$, $^{**}p<0.05$, $^{*}p<0.1$.

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activity or demand for personal services squeezes out middle wage employment and increases the number of individuals earning high wages. It is most likely that there is a simple composition effect, with wages increasing for those working in innovative industries. As labour supply is relatively fixed, there are no compensatory movements of migration into the areas, and hence innovative labour commands larger rents. While the control for migration is not significant, there is a negative effect from population density (which, given the use of fixed effects regressions, is essentially a measure of population growth), implying that where these processes of population growth may be operating it may be decreasing inequality (Korpi, 2008). This lends the model to an interpretation where innovation leads to growth, but controlling for compensating increases in population and the overall level of development, benefits go to select groups of innovators, resulting in greater inequality.

In contrast to the European results, there appears less of a relationship with inequality in US cities (Table 3). When only the innovation and inequality measures are included (columns 1–3) there is a positive relationship only between ICT patenting and inequality, significant at the 5% level. Neither the overall level of patenting or biotechnology patenting are significant.

In the full models (columns 4–6), these relationships change. There is actually a negative relationship between the overall measure of innovation and inequality, although this is not significant. The sign on the biotechnology patenting variable is positive and significant at the 10% level, while the ICT variable is significant at the 5% level (Table 3). In short, it appears that patenting is a significant driver of inequality in European regions, but there is no general effect in USA; the effect for US cities is limited to sub-sectors.

There are a number of potential explanations for this divergence between European and US results. One is that cities in Europe have less room to expand physically as the continent is more densely populated and cities often have greater restrictions on new development. This means that only those who can afford to live in relatively constrained cities can migrate there and share the processes of innovation, a process which has been observed in historic but innovative cities such as Oxford or Cambridge but which is less likely to happen in US cities (Cheshire and Sheppard, 2002). This constrains the ability of innovative European cities to expand and restricts the labour market benefits to the affluent and drives inequality. A challenge to this interpretation is that the migration variables are not significant, which may imply that migration processes are constant. But as we control for population density (in a fixed effects model this is essentially population growth) this may instead reflect a selection process, where the absolute numbers are less important than the composition of migrants. A second potential objection is commuting, with people commuting in to innovative regions rather than needing to live in them. As our data is for relatively large regions (NUTS 1 or 2) commuting is unlikely—with the exception of a small number of regions—to significantly affect our results. In short, controlling for numbers of migrants, innovative European cities may attract only the affluent or high skilled; innovative US cities may attract a broader spectrum of migrants.

A second potential explanation is that in USA those with low skill levels tend to be in employment, whereas in Europe they may only enter the labour market in certain economic contexts (Kaplanis, 2010b). With low minimum wages and restricted welfare states, the low skilled in USA are more likely to be in employment than in Europe. Innovation may create personal service employment, but this does little to the wage

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structure as these individuals are likely to be in employment anyway, and while there will be increases in their wages, these will only be small. In contrast, in the European case the welfare state provides fewer incentives to enter the labour market at low wages, while the minimum wage means certain jobs are not likely to be performed. If affluent innovators create personal service employment, these may provide sufficient incentives for low-skilled individuals to enter the labour market at relatively low wages, increasing the level of inequality.

A final reason behind the observed differences in the link between innovation and inequality in Europe and in USA is that it relates to market structures in the particular innovative sectors. Freer labour markets in USA may allow processes of labour market arbitrage, where the benefits of innovation to the individual are reduced by wage bargaining. In Europe, greater labour market regulation and unionization may allow particular groups to capture these benefits for themselves. In innovative industries employee groups may essentially act as cartels, restricting entry to others.

There is also evidence of diversity of results, which is unsurprising given the wide number of potential channels through which innovation may lead to inequality (and highlighted in Section 2), the variety of innovation systems and diverse market structures which will operate within and between these continents. Indeed, while the overall patenting variable for innovation is not significant, the results suggest a positive relationship between biotechnology patenting and inequality in USA, but not in Europe. In this case, one explanation may be that biotechnology in Europe may be dominated by state-led health service provision, and so the benefits do not accrue to individuals. In USA, the healthcare system allows a select group to benefit. This result highlights the diversity of innovation systems, with each of these diverse systems likely to lead to gains in different ways, according to whether the innovation takes place in the private or public sector, whether it is directly commercially applicable or not and the type of innovation which it represents. In contrast, ICT patenting is more likely to be in the private sector and highly internationalized, and so may have more similar market structures in both continents. Given the considerable variety of market structures, a diverse set of results are not surprising.

The remaining independent variables are also of considerable interest. High skill levels are positively associated with inequality in both USA and Europe, although they lose significance when patenting is included in the European models (Table 2) and when biotech patenting becomes significant in US models (Table 3). This means that a higher proportion of highly skilled people makes cities more unequal in USA, which may reflect lower tax rates and less redistributionary labour market institutions. It may also reflect higher levels of sorting according to ability into particular cities, through which individuals match skills with local complementarities and raise their returns (Combes et al., 2008; Glaeser et al., 2009).

Increased affluence, which—given the use of fixed effect panel methods—is effectively short term growth, appears to reduce inequality in both Europe and USA. This concurs with Kuznetsian views and other results in the literature, but contrasts with evidence which suggests there is a positive relationship between the numbers of the affluent and inequality (Wheeler, 2004a; Glaeser et al., 2009). This is an important issue for future research in this area. The divergence between short-term and long-term results in studies like this may be because both long and short term processes are operating simultaneously (Partridge, 2005).

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In neither case is migration significant. However, models (not reported here) for economic growth suggest a positive relationship with migration in both continents and there will also be a relationship between migration and population density, with population density de facto a measure of population growth. Population density is associated with a reduction in inequality in Europe, but with an increase in USA. Other research for USA has shown dense cities to be less unequal (Wheeler, 2004b), but this research did not use a panel data format.

Unemployment appears unimportant for inequality in Europe (Table 2), but is positively related to inequality in USA (Table 3). Greater levels of wage regulation in Europe may drive this result, as minimum wages and the existence of more generous state benefits essentially provide a floor below which wages may not go (Dickens and Manning, 2004; Freeman, 2007). In USA, unemployment will reflect excess labour supply and in the absence of wage regulation, this may lead to wages being bid down (Lobao et al., 1999). Finally, in Europe the measure of wage co-ordination is significant and negative. As expected, where countries have greater wage co-ordination inequality is reduced. This variable is not used in USA, as it is time invariant and so removed from the estimation.

5.2. Sensitivity of the results

As a basic check to the sensitivity of the results, Table 4 repeats the evidence for US cities for a smaller time period—that for 1996–2001, in order to make it directly comparable with the European data. The results support the general results of the article, although there is a major caveat that the sample size is reduced substantially and so fewer of the variables are significant. Once again, only patenting in biotech is associated with higher inequality and there is otherwise no relationship between innovation in the cities and the level of inequality. Given that this was a period of major increases in both innovation in USA, on the back of computerization, and also a period when inequality experienced major increases, this is perhaps a surprising result (Dew-Becker and Gordon, 2005), but confirms the general finding of this article: the weak evidence that innovation leads to inequality in US cities but strong evidence of its association with inequality in European regions is not affected by the time period for which each set of results is run.

A second issue is the negative effect introduced on the patenting variable for Europe, which changes sign from negative to positive when controls are included There is a risk of endogeneity in the models, as patenting strongly reflects other variables which might alter regional inequality. As patenting is seen as causing growth, the two most likely confounding variables are the unemployment rate and GDP per capita. In Table 5, these are introduced sequentially into the model for Europe.

The results show that the relationship between innovation and inequality is contingent on controlling for the level of economic development. When patenting is included but without the alternative measures of economic performance (unemployment and income) it is significantly negatively related to inequality. When unemployment is included, innovation is positively related to inequality, but the result is insignificant. It is only once GDP per capita is included in the regression (column 3) that the sign of the coefficient is positive and the results are significant.

In short, the impact of innovation on inequality only applies when controls for economic development are included. This may mean that there are two effects operating

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Table 4. Patenting and inequality in US cities, 1996–2001

Variables	Gini coefficient of wages		
	(1)	(2)	(3)
Median wage (ln)	−4.59e−06 (2.44e−06)	−5.83e−06 (3.20e−06)	−4.26e−06 (2.20e−06)*
Unemployment rate (ln)	0.00196 (0.00128)	0.00490 (0.00163)**	0.00274 (0.00188)
Population density	0.394 (0.490)	0.504 (0.410)	0.238 (0.444)
Population with degree, % (ln)	0.00101 (0.00103)	0.000198 (0.00271)	−8.62e−05 (0.00120)
Recent migrants (%)	0.369 (0.416)	0.507 (0.436)	0.362 (0.559)
Patents per capita (ln)	−0.00876 (0.0176)		
Biotech patent p.c. (ln)		0.0328 (0.0147)*	
ICT patents p.c. (ln)			0.0187 (0.0106)
Constant	−1.033 (1.806)	−0.939 (1.418)	−0.180 (1.579)
Observations	235	183	222
R^2	0.031	0.082	0.038
Number of cps_code	40	38	40

Robust standard errors clustered by region. Model estimated with fixed effects.
***$p<0.01$, **$p<0.05$, *$p<0.1$.

Table 5. Patenting and inequality in European regions, 1995–2001

	Full sample		
	(1)	(2)	(3)
GDP per capita (ln)			−0.0338 (0.0105)***
Unemployment rates (ln)		0.000323 (0.000724)	−0.000746 (0.000760)
Population density (ln)	−0.00905 (0.00119)***	−0.00846 (0.00107)***	−0.00871 (0.00126)***
Share of population with degree (ln)	0.000319 (0.000196)	0.000172 (0.000155)	0.000163 (0.000139)
Wage coordination	−0.00723 (0.00250)**	−0.00744 (0.00224)***	−0.00788 (0.00240)***
Migration balance	−0.455 (0.502)	−0.427 (0.609)	−0.364 (0.631)
Patents per capita (ln)	−0.00156 (0.000624)**	0.00105 (0.000913)	0.00430 (0.00148)**
Constant	0.337 (0.00772)***	0.329 (0.0120)***	0.660 (0.102)***
Observations	565	490	490
R^2	0.011	0.014	0.025
Number of cases	90	86	86

Robust standard errors clustered by country. Model estimated with fixed effects.
***$p<0.01$, **$p<0.05$, *$p<0.1$.

simultaneously. The first is that innovation leads to growth, and—as other studies have suggested—growth may reduce inequality (Wheeler, 2004a; Glaeser et al., 2009). This growth may derive from many sources beyond innovation, however, meaning that a second effect may be operating: an effect through which overall growth reduces inequality, but through which innovation alongside it leads to increased inequality. Growth may increase demand for labour of various forms, and reduce inequality as it reflects increased wages towards the bottom of the distribution.

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6. Conclusions

This article has presented the first comparative evidence on the links between innovation and inequality in US cities and European regions. The key result is that while overall levels of innovation drive inequality in European regions, this does not seem to be the case in US cities. Explanations for this may be rooted in the planning system or patterns of migration which restrict movement to those with high skill levels. Yet, there is considerable diversity in the extent to which innovation leads to inequality, reflecting different market structures and the many ways in which innovation will affect the wage structure. Differences in labour market structures and welfare systems across the Atlantic imply that in innovative European cities sufficiently high wages will entice the low skilled into the labour market, increasing levels of inequality. In USA, where welfare states are less developed, the low skilled are likely to be already in employment. Higher migration following jobs will also lure workers to innovative cities in USA. In Europe, a more restrictive planning system and lower migration curtails the growth of innovative cities, meaning the benefits are less likely to be shared (Leunig and Overman, 2008).

The second result is that innovation in particular sectors will have different effects on inequality. While patenting overall only appears to drive inequality in Europe, innovation in some sub-sectors leads to inequality in USA. These differ continentally, with biotechnology leading to inequality in USA but not in Europe, while innovation in ICT is the key driver of inequality in both Europe and USA. More work is necessary to consider the drivers of these effects, but it may well be due to the differences in market structures between the two sectors. These will have a complex interplay with other factors, such as the potential for selective migration, at a local level.

There are also clear differences in the determinants of inequality between Europe and USA. Education has a greater influence on inequality in USA than in Europe. Similarly, population density seems to drive inequality in USA, but reduce inequality in Europe. In both cases, greater income is connected to a reduction in inequality. These results reflect the paradox in the literature on growth, affluence and inequality. Other studies have shown that more affluent cities tend to be more unequal (Glaeser et al., 2009). Yet, research also suggests that growth tends to reduce inequality (Wheeler, 2004a). The nature of the panel regression model is that this is essentially investigating changes in income over time, and so is a measure of growth. One process which may be operating is that growth bids up wages for those with lower skill levels (Kaplanis, 2010a).

There are, of course, a number of limitations to the research presented here. The comparison between regions and cities has been the focus of other similar comparative research (see Crescenzi et al., 2007) and is the best available, although it is limited in some cases. Using functional urban regions for Europe may be a more appropriate comparison, but this is unfortunately not possible in this case as the data is not available at the correct scales (Cheshire and Magrini, 2000). Other studies have shown that the ECHP, while useful, tends to have relatively high levels of measurement error at a regional level. A second problem is the nature of the dependent variable, for which this article has considered only wage inequality. Wider processes of income and wealth inequality may also be operating.

The article also suggests a number of potentially important new avenues for research. First, future research should consider the findings of this article using alternative data. One way of doing this would be to use microdata to construct measures of urban inequality at a more local level which can be decomposed into an effect of composition

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and an effect of differential rewards for particular groups may help answer some of these questions. The limitations of available cross-national panel data may mean that using cross-sectional data may be the only possible way of doing this. Secondly, the diversity of forms of innovation, a key feature of the innovation literature, needs to be reflected in future studies of this important issue. This article has found diversity of effects from one indicator of innovation, patenting; other effects may operate from process innovation or other measures of product innovation. Third, within both Europe and USA there will be different configurations of employment and welfare regimes (Gallie, 2007). Investigating how national and sub-national differences alter the link between innovation and inequality may yield further insights.

Acknowledgements

We are grateful to the editor, Neil Wrigley, and to the anonymous reviewers for insightful suggestions to earlier versions of the paper. Our thanks to Riccardo Crescenzi, Smita Srinivas, Robert Beauregard, Jürgen Essletzbichler and Jason Beckfield for helpful comments and suggestions. Neil Lee acknowledges the support of Columbia University, where he was a Visiting Scholar while writing this paper.

Funding

Financial support by the European Research Council under the European Union's Seventh Framework Programme (FP/2007-2013)/ERC grant agreement no. 269869 and of a Leverhulme Trust Major Research Fellowship is gratefully acknowledged.

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